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THE CAUSES OF THE DEVELOPMENT OF ANCIENT CIVILIZATION IN ARID COUNTRIES.

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It has been noted as a curious fact that the majority of the ancient civilizations developed precisely where nature imposed the onerous condition of artificial irrigation upon the husbandman, who supplies the prime necessaries of life. Aside from Egypt, the permanent fertility of which is ascribed to the inundations of the Nile, we find to the westward the oases of the Libyan and Sahara deserts, whose high fertility has become proverbial, and caused them to be cultivated from ancient times to the present. Similarly, in southern Europe and northern Africa, we find that, instead of the humid forest country, it was in the arid but irrigable coast regions—such as the "vegas" of Valencia, Alicante, Granada, Malaga, the Græco-Syrian archipelago, and, on the opposite shores, the even more arid domain of which Carthage was the metropolis—that noted centres of civilization were developed and maintained. We observe the same phenomena in the other continents, and nowhere more strikingly than in Asia, credited with being the cradle of mankind. The arid belt requiring irrigation extends from Egypt and Arabia to Palestine, Syria and Persia, across the Indus and through the anciently recognized regions of Indian civilization—Sindh, the Punjab, Rajputana and Northwestern India—to the Ganges, embracing such well-known centres as Lahore, Delhi, Meerut, Agra, etc., and inhabited by much more hardy and progressive races than the highly productive and humid tropical portions of the Indian peninsula. Throughout this extensive and important region, irrigation is necessary in order to maintain regular production, and in default of it, periodic famines ravage the country. Thousands of years ago, millions of treasure were spent upon irrigation works, as has been again done in modern times; yet, in the rainy, forested districts we find even yet large areas tenanted mainly by wild beasts. In Central Asia, as well as in Asia Minor, the ruins of ancient cities are seen where at the present time only the herds of nomads pasture. The khanates of southern Turkestan, with their historic cities, illustrate the same obstinate bias in favor of the arid climates. Nor is it otherwise in the New World. It was not the moist, exuberantly fertile forest regions of the Orinoco and Amazon, but the arid western slopes of the Andes, that developed the civilization of the Incas. In Mexico, similarly, it was the high central plateau, not the bountifully productive *tierra caliente,* over which the Aztecs chose to extend their dominion. Even to the northward, the inhabitants of the high, dry plains of Arizona and New Mexico were (as their descendants inhabiting the *pueblos* still are) superior in cultural development to their forest-dwelling neighbors of the Algonquin races; from time immemorial they have practised cultivation with irrigation, maintaining a comparatively dense population on very limited irrigated areas.

It was evidently not merely the stimulus of the struggle for existence that conditioned this remarkable phenomenon. It might be thought that the desire to avoid the labor of clearing forest ground was the motive which impelled ancient culture toward the choice of treeless regions. But if we consider the labor and cost of establishing and maintaining irrigation ditches, it certainly seems that a stronger motive, based on the intrinsic nature of the case, must have influenced the choice.

It appears to the writer that such a stronger motive may be found in the higher and more permanent fertility of the arid lands, whenever water is adequately supplied.

That arid soils should be more fertile intrinsically can be forecast *a priori,* when the processes of soil-formation in the arid* and humid regions are comparatively considered. That this has not been done until within recent years is one of the curious lapses which we occasionally find in the progress of science. This is not the place for a detailed consideration of these processes; but the essential differences between the humid and arid regions may be briefly characterized in a manner intelligible to the layman in soil chemistry, since the general conditions of agricultural productiveness have now become a matter of popular knowledge.

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* By an "arid" climate is meant not merely one deficient in total rainfall, but especially one having practically rainless summers. Two belts of this character exist, intervening between the tropics and the temperate humid regions of summer rains, both north and south of the equator.

Soils are formed primarily by the physical and chemical disintegration (weathering) of rocks, and these processes continue in the soil mass. They result in the formation of a certain proportion of water-soluble compounds, chiefly of sodium and potassium, also of calcium and magnesium. Wherever abundant rains occur more or less regularly throughout the year, these water-soluble compounds are leached out of the land, passing into the sub-drainage, and thence through springs, streams and rivers into the sea. But where the rainfall is scanty, this leaching can take place only partially or not at all; and we frequently find, during the rainless season, the salts of potassium, sodium and magnesium appearing as a superficial "bloom" or efflorescence on the land surface, being brought up by the evaporation of the soil moisture—sometimes in such amounts as to prevent the growth of ordinary vegetation, and permitting only that of "saline" plants. For, with the useful, nutrient substances, of course also the useless or injurious ones, such as common and Glauber's salt, and sal-soda, are left in the land. These "alkali" lands form the extreme contrast to the intensely leached, usually "red," lands of the tropics, known as laterite soils; which are extremely poor in plant-food ingredients.

But, while an excess of these salts is injurious to useful vegetation, it is obvious that, where such excess does not occur, there must be formed in the soils of the arid regions accumulations of plant food which may render it possible to defer for a long time the need of artificial fertilization, to which the farmer of the humid regions must devote so much money and energy.

So much might have been inferred *a priori*. But that this state of things actually exists, the writer has demonstrated by the comparative investigation of a large number of soils from the arid and humid regions of the United States. These investigations, with some of the conclusions flowing therefrom, were first published in Bulletin No. 2 of the United States Weather Bureau, in 1892, and more extendedly in subsequent publications.* From these the following points, which have been abundantly verified since, may be briefly summarized.

Recalling to mind that the soil ingredients drawn upon by crops that require replacement by fertilization are potash, phosphoric acid, nitrogen and lime (or the elements potassium, phosphorus, nitrogen and calcium), it appears that:

1. All arid soils are calcareous (with a few local exceptions arising from the absence of calcium from the parent rock); that is, they contain a sufficient supply of lime (carbonate) to realize all the advantages known to belong to such soils, and which in the humid region it is sought to bring about by the costly process of liming or marling. On the average, the lime-percentage of the arid soils of the United States exceeds that of the lands of the humid region (where not specially supplied by underlying limestone formations) from twelvefold to fourteenfold.

2. All soils of the arid regions contain large amounts of potash in forms readily available to plants; aside from the actually water-soluble salts of potash always present in the "alkali" salts, sometimes to the extent of over twenty per cent. of the latter. Thus the need of fertilization with potash is, under ordinary cropping, almost indefinitely postponed.

3. Nitrates, the formation and leaching-out of which are a source of continuous and heavy losses of soil-fertility in the regions of summer rains, accumulate in the soils of the arid regions, so as sometimes to form over forty per cent. of the soluble salts in the soil, and as much as 1,200 pounds per acre. Even ammonia salts are sometimes present in notable amounts. Humus, the repository of the nitrogen supply of soils, is usually present only in small amounts in arid soils, but is on the average three times as rich in nitrogen as that existing in humid soils.

4. Phosphoric acid, the fourth of the plant-food ingredients usually supplied in fertilizers, is not more abundant in arid than in humid soils, not being subject to leaching-out. But in alkali lands we frequently find water-soluble phosphates, ready for root-absorption, circulating in the soil in notable quantities.

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* See Wollny's "*Forschungen auf dem Gebiete der Agriculturphysik,*" 1893; "*Annales de la Science Agronomique,*" 1893; "Reports and Bulletins of the California Experiment Station," 1894 to 1902; "*Verhandlungen des Internationalen Geographen-Congresses, in Berlin,*" 1901, and elsewhere.

Thus frequently the watery extract of arid soils is of just such composition as the nutritive solutions compounded for the purpose of growing plants experimentally; and it is hardly necessary to say that such lands repay cultivation with extraordinary crops, so soon as the several sodium salts, mentioned above, are removed, or rendered innocuous by other means. It is no wonder that, as the Russian traveller von Middlendorf relates, the natives of Ferghana carry the alkali crusts from the lower grounds to the higher by donkey-loads, saying that "the salt is the life of the land." It is only the excess that is damaging; and the extraordinary productiveness of reclaimed alkali lands justifies considerable expenditure toward such reclamation. There are but few such lands that will not ultimately amply repay the cost.

Among the readiest means for that purpose is the neutralization of the carbonate of soda ("black alkali"), when present, by means of gypsum, which converts it into the relatively innocuous sulphate, or Glauber's salt; while, at the same time, it retains the previously dissolved humus and phosphates. Common salt, unfortunately, can be disposed of only by drainage, which, however, removes a corresponding portion of water-soluble plant-food, potash salts, nitrates and phosphates.

There can be no doubt, then, that arid regions offer to the husbandman not only unusual but also lasting productiveness as the result of the application of irrigation water, in consequence of the accumulation of plant-food in the soil. But the advantage does not end there; for it is one of the peculiarities of rock-weathering under arid conditions that there is very little true (plastic) clay formed; and hence the soils are throughout of a sandy, or rather powdery, nature, which manifests itself unpleasantly in the well-known dust storms of the deserts. As a consequence of this, and of the deficient rainfall, there is practically little or no difference between the arable soil on the surface and the underlying subsoil, sometimes to the depth of ten or more feet. Hence, air as well as water can penetrate to these depths unhindered by dense, impervious subsoils; and with them the roots of crops penetrate habitually to similar and greater depths, and can there exercise their nutritive functions. This means that, instead of two or three feet, from three to five times that amount of soil mass is ready to be drawn upon by plants; so that the purchaser of a given surface-area of land really obtains, in the arid regions, several times as much productive land as he would have received in the humid. And while in the regions of summer rains the sandiness of the soil is closely correlated to infertility, because there sand consists essentially of quartz grains only, in the arid regions "sand" is the entire substance of the parent rock, more or less decomposed, and constitutes soils as "strong" as the best clay lands of the humid countries, so soon as it is irrigated.

All this explains rationally the high production of irrigated land in the arid region, and the fact that a much smaller unit of land-holding can and does prevail there, the land thus supporting a much denser population. Already, in Californian irrigated colonies, from ten to twenty acres is the unit offered to a family, instead of the 40 to 160 considered needful in the humid portion of the United States. The comparatively high prices of irrigated lands are the natural result of these intrinsic advantages, of which, however, not every newcomer knows how to avail himself.

It is hardly doubtful that the ancient "*Kulturvölker*" recognized these advantages by experience, and eschewed the laborious task of rendering cultivable the comparatively infertile, or, at least, readily exhausted, lands of the forest regions; where, moreover, an unseen enemy might lurk behind every tree. And it is also clear that, inasmuch as the establishment and maintenance of irrigation canals necessarily involve co-operation, and therefore a rather high degree of social organization, the conditions of the arid regions were exceptionally conducive to the establishment of the highly complex polities of which the vestiges are now being unearthed in what we are in the habit of calling "deserts." It is also quite natural that these wealthy and prosperous communities should have excited the cupidity of the "barbarous," forest-inhabiting, warlike races, and should, as history records, have been over and again overwhelmed by them—a similar fate often afterwards overtaking the conquerors after the Capuan ease of existence had weakened their warlike prowess. At the present time, the arid regions of the Old World are still largely suffering from having been overrun by the nomadic Turanians, whose original habitat—Mongolia and Turkestan—while also arid, does not permit of the ready and full realization of the advantages above outlined, on account of the rigorous climatic conditions. The advent of Mohammedanism, while on the one hand conducive to a vast improvement in civil and social polity, as compared with the idolatry and fetichism which it is even now successfully superseding in Africa, first expelled, and has since repelled, Western civilization from the arid regions of the Old World, and remains there to-day as an obstacle to its progress. But Islam now seems likely to lose its power of repulsion through the peaceful aggression of railroads in its old strongholds; as in Egypt, it seems likely to be shorn of its claws in Turkestan, Asia Minor, Persia, and eventually in Arabia; and the bitter fanaticism even of the Tuareg tribes is giving way before the French highway from the Mediterranean to the Niger. When Timbuctoo becomes a transcontinental railway station, and Constantinople and Bagdad are linked together by steel bands, the Desert will soon lose its terrors, and the Bedouins and Koords will, as did the formidable Tekke of Turkestan under the influence of the Transcaucasian railway, adopt the arts of peace and make Mesopotamia and Babylonia garden lands, as of old, under the abundant waters of the Tigris and Euphrates. Doubtless, there is not water enough available for irrigation in the arid zones of the world to irrigate fully more than a fraction of the whole. But the high and lasting productiveness of that fraction, together with the more rational use of the unirrigable lands, will defer for a long time the fulfilment of the unpleasant forecasts made by Malthus, and latterly by Crookes. The intense production of foodstuffs now resulting from the copious use of fertilizers in the humid regions, can for long periods be maintained with the use of water alone, in regions where, though now classed as deserts, "the salt is the life of the land." Their soils and climate have not changed; but political misrule, following their invasion by warlike nomads, has paralyzed agricultural and social progress. The tide of civilization which has risen so high in the forest countries of Western Europe, will not recede, but will overflow into the arid countries, and revive, only on a higher plane, the pristine flow of milk and honey that, much critical speculation notwithstanding, made Palestine the Promised Land.

E. W. HILGARD.